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Michael S. Hopkins

The 4 Ways IT is Driving Innovation

An interview with Erik Brynjolfsson

“MIT Sloan economist and digital-business expert Erik Brynjolfsson tells how the rising data flood, and emerging tools for analyzing it, are changing the ways innovation gets done.

There’s always been a performance gap between companies that embrace technology and companies that resist it—what IT innovation thinker Erik Brynjolfsson calls the productivity gap between “leaders and laggards.”

What’s new is that while the gap was fairly steady for decades, in 1995 it suddenly started to widen—and is widening still. Credit the rise of systems like ERP (enterprise resource planning), the expanding use of the Internet, and the fact that every dollar buys incrementally more computerization.

Brynjolfsson found not only that the leader-vs.-lagger gap has grown in the past decade, but that it has grown most in IT-intensive industries. Why? Because the leaders are capitalizing on technology advances to pioneer a whole new innovation paradigm, based on the ways they measure, experiment with, share, and replicate information.

In a conversation with MIT Sloan Management Review editor-in-chief Michael S. Hopkins, Brynjolfsson, the director of the MIT Center for Digital Business and the Schussel Family Professor at the MIT Sloan School of Management, talks about how smart companies have learned to tap the flood of data created by information technology and process it with what he calls a “higher information metabolism.” And how they’re changing the ways that innovation gets done.

Your research and work with the MIT Center for Digital Business focuses on the ways that information technology is linked to innovation. Let’s start with your big picture overview.

In the long run, our competitive advantage and all of our living standards depends on innovation, and I would argue that for our era, the most important driver of innovation is information technology. Thanks to Moore’s law, the

The Leading Question

How are IT advances changing innovation?

Findings

- * Tech advances aren’t just innovations in themselves. They’re enabling a new process for innovating.

- * There are four aspects to the new innovation process: measurement, experimentation, sharing, and replication. Each is useful individually. The real power is in combining them in sequence.

- * Leading companies do less long-term planning and more tech-enabled sensing-and-responding. They have quicker cycle times, more flexibility, and a higher metabolism for processing information.

adjusted power being delivered, for instance, by computers, has grown tremendously. That directly has led quantifiable increases of productivity.

Information technology is also a catalyst for complementary changes: it's what economists call a "general purpose technology" which sets off waves of complementary innovations in things like business processes, new ways of reaching customers, new ways of connecting to suppliers, internal organization to the firm. These complementary changes are often ten times as large as the size of the initial investments in the IT itself and have profound and long-lasting effects on our ability to create goods and services.

But there's a factor that has not been studied very much and, frankly, is not very well understood. And that is the possibility that IT can change the innovation process itself.

This is something that we haven't seen much in the economic literature. But when I go and visit companies, I see it happening all the time in the 10 or 20 percent of businesses that are on the leading edge. And the way that they've been changing innovation is, I think, a harbinger for some more profound changes in the economy as a whole.

Is it that companies are using information technology to measure what they do in especially smart ways?

Yes, but it's not just measurement. IT is setting off a revolution in innovation on four dimensions simultaneously: measurement, experimentation, sharing, and replication. Each of these is important in and of itself, but, more profoundly, they reinforce each other. They magnify the impact of each other. Improved measurement makes experimentation much more valuable, which in turn becomes more valuable still if you can share those results to the other locations. And, ultimately, if those results are important, you want to be able to scale those results up.

By doing all four of these changes together, companies are, in essence, creating a new kind of R&D.

Let's go through those four one by one. The first, you've said, is measurement.

It's more like radically improved measurement, through the use of what I call nano data. That includes clickstream data, Google trends, detailed email data, the billions and trillions of bits of information that are thrown off by enterprise planning systems. Even without any conscious effort on the part of the designers, this information is just generated. But by studying these data very carefully, companies can have much better knowledge of their customers, of their business processes, of their product quality, and of defects of their supply chains. The field of business intelligence has been tapping into this explosion of data.

If companies are measuring information, then they have the means to use IT to experiment with things like how they're selling to their customers. You say that's the second category of IT-driven innovation.

Yes. IT-based experimentation is most obvious in companies like Amazon, which regularly conducts what it calls "A/B experiments," tests of its web pages that deliver different versions of the same page at the same time to different visitors, monitoring customer experience and follow-through. Google, similarly, does 200 to 300 experiments on any given day. But it's also quite common in catalog companies, like credit card companies and direct mail companies, and even in mainstream brick and mortar companies like the casino chain Harrah's.

The big advantage of an experimental approach that uses IT is that you can get at causality in a way that you can't with just pure measurement and observation. And that, of course, is the gold standard for being able to have actionable knowledge about what's really happening in your business, what innovations are paying off and which ones aren't.

I'll ask you about that Harrah's example in a minute. Let's first talk about the other two dimensions you mentioned, sharing and replication.

A third thing that's changed a lot in businesses over the past five to ten years is the way that companies can share not only data, but insights. The internet and information technology is uniquely well designed for this kind of sharing, of course.

An example is what happened spontaneously at Cisco Systems, where the central IS department did not support Macintosh computers. There were about 10,000 users of Macs, and they set up their own wiki internally to share tips and tricks on things like how to install new software and how to get their Macs to work with the company's Linux printers. This creation of a wiki shows how not just big innovations, but smaller ones, like figuring out how to network with a printer more quickly, can be easily shared.

We often think of grand innovations, like the invention of the light bulb, as what drives economic growth. But equally important, and perhaps more important, are the 1,001 small innovations that regular business managers and line workers do every day at their jobs. If we can find more effective ways of sharing those micro-innovations with one another so that each person doesn't have to reinvent the wheel or reinvent the printer routine, then we're much more likely to be able to get a faster, more steady pace of economic growth—and improved competitive advantage for the companies that make that easy.

The fourth change is replication. What do you mean by that?

IT makes it dramatically easier to replicate and scale up innovations once they've been identified. The first three approaches help companies find and share new innovations, but then IT makes it possible to take that innovation and copy it many times.

Now, the most obvious examples are innovations that are made of bits, like software and music and web pages. Those get replicated thousands, hundreds of thousands, millions of times, and that process of replication has obviously completely changed those industries.

However, what we also see is that business processes themselves can be replicated by leveraging information technology. A nice example is what Andrew McAfee at our Center for Digital Business described in his study of CVS. The company implemented an improved business process for prescription drug ordering at one of its pharmacies, which improved customer satisfaction significantly. But what happened next is what's really important. Managers took that business process and embedded it in an enterprise information technology system, and then they replicated it to 4,000 other pharmacies in 4,000 other CVS stores within a year.

We're seeing that not just in retailing but also in manufacturing, in banking, in industry after industry.

Let's go back to Harrah's. You say it's an example of an offline company—not an Amazon, but a business with staff people who interact, in person, with customers in the real world—that has used IT in all four ways to drive innovation. What is Harrah's doing now that it wasn't doing before?

The CEO there, Gary Loveman, was a PhD student here at MIT with me. And I think he's an exemplar of a new kind of senior executive that we're going to be seeing in the coming years. Gary has created a culture where employees at Harrah's are regularly doing business experiments and carefully measuring their results through their information systems. The successful findings are shared with business managers at other locations and then scaled up to become part of corporate policy going forward.

When he first came to Harrah's, it was, frankly, sort of a second-tier, also-ran casino company. But it did have a great deal of data. Most of that data was not being used effectively, and he brought a culture of experimentation and analytics that has propelled Harrah's to being the leading casino company.

How did he do it? Well, he's really good with numbers. And while a lot of his competitors were working on having fancier fountains and more incredible spectacles in Las Vegas, Gary was checking through the numbers to see what was really driving profitability. This kind of analysis is something that he has spread not just into the CEO suite, but all throughout the company.

In fact, when he came to speak at my MBA class last year, he told me that there were really just two things that could get you fired from Harrah's. One is if they catch you stealing from the company. The other is if they catch you running an experiment without a proper

control group. Now, that kind of culture, of taking experimentation and methodology that seriously, is something new—and something that IT makes a lot more feasible.

So, Harrah's runs dozens of experiments. For instance, they will see whether different kinds of discounts and coupons can entice people that normally come for two days to come for three days, or get people who normally bet the \$5 machines to bet the \$25 machines. They bring experimentation to figure out what work practices can get their waiters and waitresses to serve customers more effectively and get higher customer satisfaction scores. This is a mentality that they bring to every aspect of their business.

It's interesting that Loveman studied at MIT before he became CEO at Harrah's. What kinds of training or changes in attitude do think this "new kind of senior executive of the future" will need?

One of the things that I see changing is a shift from a lot of long-term planning. Instead, there's more sense and respond: experiment so that you can learn about what your customers' needs are, what the supply chain changes are that could make a difference, how to redesign your products.

This is a mentality that requires much quicker cycle times. It requires people from the organization to be flexible and nimble. It requires a much higher information metabolism.

You have to have really high quality, intelligent people working for you who are getting the data they need to be able to make rapid decisions and then propagate the effects of those decisions equally rapidly.

You know, to be successful at this experimentation approach requires a unique set of skills, one that hasn't been that common among most types of managers, and one that, frankly, we at business schools need to work harder at bringing together. Specifically, these managers need knowledge of business analytics, the way to understand the numbers to drive the statistics and to design intelligent experiments—but also deep knowledge of the business itself, to know how to ask the right questions.

In coming years, I think the real bottleneck will be finding people who combine those sets of skills, who can design experiments that get at genuine business problems in a way that can be analyzed through controlled business experiments. That's something that we don't see a whole lot currently.

In theory, companies have had access to data and been doing experiments forever. Isn't the big problem—or, let's call it the big challenge—that there's just so much information that it's hard to know where to start?

I think so. Most companies have just been overwhelmed with the flood of data that's been created by their information systems. Much of that data arrives almost accidentally, when

they install, say, a new enterprise resource planning system. Suddenly billions of bits of information are generated about their operations, about their customers, about their suppliers. And most of it just gets stored, never used, never looked at again.

Gary describes coming to Harrah's as finding a gleaming new F-16 fighter, but with no pilot. Just all this wonderful data that had nobody to steer it and take advantage of it. And I think that's more the norm than the exception at companies as they implement information systems. The original systems often have very specific operational goals, but ultimately, the data that they generate may be even more important if it leads to innovations and changes in business practice.

What we're going to see in the coming decade are companies whose whole culture is based on continuous improvement and experimentation—not just of specific processes, but of the entire way the company runs. I think this revolution can be fairly compared to the scientific revolution that happened centuries ago. Great revolutions in science have almost always been preceded by great revolutions in measurement. Management historically has not had that kind of careful measurement or experimentation. But it's time that we catch up.

Sounds like a massive opportunity. Where do companies start?

Well, like I've described, companies are going to have to nurture a mentality of experimentation, an expertise in how to run those kinds of business experiments, and an infrastructure that makes it possible to replicate and scale up successful innovations.

Paradoxically, this leads to a simultaneous centralization and decentralization of decision making. On one hand, the opportunities for innovation and experimentation need to be decentralized, because only the people who are on the spot are going to have the local, specific knowledge to know what kinds of experiments are likely to be valuable. On the other hand, to be truly successful, companies will have to find ways to embed the resulting innovations into a platform that can be scaled up and replicated. That's easy to do in digital companies like Amazon or Google, and a little harder to do, say, in retail or manufacturing companies, but it can be done through the aid of enterprise information technology. Many business processes can be embedded in these systems. And when you find a better way of managing that process, if it can be leveraged or even fully embedded in a business process, it can be replicated. So, centralization of those parts of the business, with decentralization of the discovery phase.

We've started calling these companies "digital organizations." For my book with Adam Saunders, *Wired for Innovation* (MIT Press, 2009), we identified their characteristics through a survey of several hundred companies. Over time, I think we'll be able to get more nuance on when companies are likely to be most successful. But we've summarized what we know so far in this book.

What will be most difficult?

I think we're furthest along in having a platform for replicating and scaling up the experiments. Enterprise resource planning systems are a great example of that.

The skill set is one that we're in the process of working on. Frankly, it's going to take a generation to fully work its way through. It's not just knowledge of the experimental design and the mathematics to handle statistics and to understand what the data are saying. It's also a culture of creativity to be able to bring together those kinds of hard skills with the flash of insight, the ah-ha moment that comes from really knowing your business, knowing your customers, and bringing those two together. That is, unfortunately, a fairly rare combination. It's one that I think that we at business schools can do more to teach and bring to businesses.

Changing culture is probably the most difficult challenge. It requires a tolerance for failure and a desire to have employees try new things. Greg Linden, who was at Amazon for a while, has said that genius is the fruit of a thousand failures. That's different than the old mentality of figuring out all the possibilities and then locking in on one. Instead, it's an approach of rapidly prototyping many different options, seeing which ones pan out, and using the information infrastructure to get the feedback quickly. Cutting the losses quickly, pruning the failures, and then ramping up the successes.

What do you see as the biggest impediments for companies?

The reality is that most organizations are like a finely tuned watch. My watch has got little gears inside of it. It's a mechanical watch. If I wanted to make this a digital watch, I suppose I could open it up and get some integrated circuits from a digital watch and kind of put them in there one-by-one. But that would not make this keep better time. That's not the way to create a digital watch from an analog watch.

Yet many people think that you can take an existing organization that's based on 20th century principles and add some of the elements of successful digital organizations one-by-one and get a more successful digital organization. I wish that were true, but in most cases that only makes things worse.

What's required is an understanding of how all these components fit together. Half the battle is understanding that changing just an incentive system or a hiring practice or a technology infrastructure by itself is unlikely to lead to desired results unless all the other components are also matched together.

Now, trying to change that many things simultaneously is a daunting task. What companies can do to manage the scope a bit is to reduce the dimensions of change on some other dimensions. They can focus on a particular geography or a particular product line.

Have you seen this work in real time?

Yes. One company I worked with wanted to change the way its factories ran from a 20th century tailorist approach to what they called modern manufacturing. It involved changes on a dozen specific practices that they had identified, from incentive systems, training, and inventory flow to product mix and technology. Eventually, they implemented the new technology and business practices in a new location, isolated from the old workforce and old physical surroundings. They got the new system to work quite well in this new location, and over time, they back-propagated it to their other locations and were able to get the new system to work throughout the entire organization. But it was something that required them to, on one hand, make lots of changes simultaneously, and, on the other hand, isolate those changes from the rest of the organization so that they could focus on them to get them to work.

I really think that the way that companies implement business processes, organizational change, and IT-driven innovation is what will differentiate the leaders from the laggards. Rather than leveling the playing field, IT is actually led to greater discrepancies. In most industries, the top companies are pulling further away from the companies in the middle and the bottom of the competitive spectrum. Rather than having a compression, we're seeing a growing spread in performance on multiple dimensions.

We're in a period of tremendous change and turbulence. People have called this The Great Recession. But it's been said, "In chaos, lies opportunity." And when historians look back on this era, I think many people will call it not just The Great Recession, but perhaps The Great Restructuring because of the way that businesses are changing how they're working and because of the central role that IT has in driving some of those changes.

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